LAND-USE/TRANSPORT INTERACTION MODELLING WITH TRANSTEP

R.J. NAIRN, J.F. FIELD & G.R. PARKER

ABSTRACT: *The paper sets out the theoretical basis for TRANSTEP and describes case studies where it has been applied.*

TRANSTEP is an inexpensive sketch planning model, which derives changes in travel patterns due to land-use or transportation system changes. It derives zonal trip generation rates and trip length distribution characteristics from zonal activity distribution and skims, before distributing trips to form a trip matrix. It is, therefore, suitable for impact evaluation.

Further, one TRANSTEP module derives changes in zonal population density due to accessibility changes and, therefore has been used to predict population growth patterns in urban areas. TRANSTEP graphically outputs contours showing zones of imbalance between employment and potential for employment derived as the probable trip-end density.

Plotting the distribution of accessibility and other parameters enables the land-use planner to service equity motives during structure planning exercises and TRANSTEP classifies these parameters by socio-economic classifications if required to assess, equity criteria for, say, income class as well as geographic distribution.

TRANSTEP has been used in Albury-Wodonga Structure Planning, Canberra Structure Planning, testing the impact of new rail proposals in the Parramatta Region and for Melbourne's proposed ring route freeway. If authorities agree examples of these applications will be included in the paper.

The paper will conclude with recommendations classifying the types of problem for which TRANSTEP is most suitable and outline intended future development of the model.

1. INTRODUCTION

1.1 OBJECTIVES

Necessity is the mother of invention and, in this case, necessity arose because the Australian Growth Centre programme produced evaluation and planning problems which accentuated most sharply the deficiencies of land-use and transportation models available in Australia in 1973.

The planning of Growth Centres required models which:

(a) Required little data and less calibration but were transferable, cheap to operate and involved quick turnaround to cope with the evaluation and planning of many land-use alternatives.

(b) Were sensitive to express changes in the travel task that resulted from changes in the land-use system as well as the transportation system. This would enable the full value of consumer surplus changes to be expressed in the economic evaluation of the Growth Centres.

(c) Were oriented to the production of outputs to direct activity distribution planning rather than only the planning of transportation facilities.

(d) Provided outputs which enabled equity or distributional analysis of land-use plans either by category analysis or by geographical plotting.

(e) Were easily adaptable to work in either static or incremental planning modes so that they can be used to optimise a plan in a fixed year or alternatively describe growth paths in the achievement of a plan.

TRANSTEP is a land-use/transport interactive package which attempts to achieve these specifications. It is also useful for a variety of other applications, such as the prediction of travel or land-use impacts of proposed new transportation or other facilities including the prediction of induced travel.

1.2 CONTENTS

This paper is divided into several sections to suit the requirements of different readers. Those interested in the mathematical formulation of the models in TRANSTEP should turn to the next section, which describes how the modules in the package operate. Those who wish to pass over this section should simply note that there are several innovative sections of TRANSTEP as follows:

(a) Trip length frequency distribution and trip generation are dependent functions of both the land-use system and the transportation system and the effects of changes in these systems are separately identified.

(b) The trip distribution function is a major improvement on the Gravity Model because the calibration function, being independent of the land-use/transportation system, is transferable in time and location.

(c) The incorporation of the latest analytical equilibrium assignment model into the TRANSTEP context provides an opportunity for assessing congestion effects on the land-use system.

(d) The incorporation of socio-economic category analysis greatly enhances the process of equity and distributional evaluation.

The following section, which describes how TRANSTEP has been used in different modes of application may be of less interest to researchers who may wish to pass over to the appendices, which discuss the validation and testing of the model's functions and sets out several interesting technical side-issues.

1.3 SCOPE

The total TRANSTEP package contains the following capabilities:

(a) Network build and skim.
(b) Develop generalised cost skims.
(c) Create opportunity functions from land-use data and skims
(d) Calculate zonal trip length probability functions.
(e) Calculate zonal trip generation rates.
(f) Calculate trip-end potentials for attraction activities.
(g) Calculate trip-end potentials for production activities.
(h) Distribute trips
(i) Mode Split.
(j) Assign and skim.
(k) Iteration.
(l) Graphic output.
(m) Equity category analysis.
(n) Efficiency analysis.

These activities can be used in either a static or incremental mode. The package also contains modules for:

(o) Population distribution.
(p) Economic evaluation.

In these modules the operating mode is fixed - the population distribution module must be used in an incremental mode and the economic evaluation module brings together the results of several passes of the package into a time series evaluation.

The package is separable into a number of discrete modules which can be used independently - such as distribution, mode split, assignment, graphic output etc. Care should be taken, when using the package, to examine the consistency of the time-equilibrium reference frame of each of the modules used together in any equilibrium application. See Appendix 5 for discussion.

The package also contains a series of user-oriented modules, as follows, some of which are not described in this paper:

(q) Update land-use.
(r) Matrix transpose.
(s) Network, skim and trip table format conversion.
(t) Calibration.

1.4 ACKNOWLEDGEMENTS

The package has been developed jointly by the authors as employees of De Leuw, Cather of Australia Pty. Ltd. and later of R.J. Nairn and Partners Pty. Ltd. Both firms by agreement, jointly hold proprietary rights to the package.

Much of the development work has been carried out by agreement on projects conducted for the Cities Commission, the Albury-Wodonga Development Corporation, the Urban Transport Study Group of New South Wales and the National Capital Development Commission and the authors are grateful for the assistance and helpful criticism received from officers of these Authorities.

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The authors are also particularly grateful to Dr. M.R.Wigan of the Australian Road Research Board for his assistance, in the form of reference works and advice, concerning the equilibrium assignment module based on the method of feasible directions.

2. TRANSTEP MODEL FORMULATION

2.1 INTRODUCTION

The total TRANSTEP package encompasses a comprehensive range of transportation and land-use modelling. Within the TRANSTEP framework there are three broad functional areas:

(a) Development of Input Data.

(b) Production of Travel Patterns and Land-use potentials.

(c) Evaluation and display.

This section deals with the conceptual framework of TRANSTEP in deriving the travel patterns and land-use potentials and briefly describes the population distribution module, which is included within the functional area of data development, and the equity category analysis and economic evaluation modules, which are included within the evaluation area.

The TRANSTEP travel patterns model has been developed over a period of time. However the basic conceptual objectives of the package have remained fixed throughout the development process.

The objectives for the TRANSTEP package are broadly to:

(a) Be sensitive to the interactios between land-use and the transport network.

(b) Be behaviourly related to key urban decision-making processes.

(c) Be sensitive to the equilibrium balance between the supply and demand relationships that exist within a transport network.

(d) Acknowledge the simultaneous nature of the travel decision process, avoiding independent or sequential models.

(e) Use empirically derived relationships rather than abstract theoretical functional forms.

(f) Be conceptually simple yet accurate.

(g) Be transferable between projects and cities.

(h) Require a minimum of input data.

(i) Be inexpensive to use.

(j) Be easy to use and learn.

(k) Provide output which is easy to both assimilate and analyse.

While every modeller would basically have the same objectives, it is believed that TRANSTEP meets rather more of these objectives than is usual.

2.2 THE ACTIVITY PATTERNS MODEL

The basic building block from which the TRANSTEP process begins is the trip length probability distribution for a particular location in the land-use/transport system.

The trip length probability distribution indicates the probability that an individual traveller will choose to travel to any other point in the system. If the behaviour of all individuals is aggregated at that location then a trip length frequency distribution will be built up. This distribution will indicate the aggregate trips which are desired to all other points in the system.

Both the probability and frequency distributions will vary for every point in the system, and for each of the different purposes that the trip may satisfy. The distributions are normally expressed as functions of a generalised cost which describes the "cost" of travel between the origin point and the full set of destination points.

The basic assumption that trip length distribution functions are the prime determinants of the resultant travel patterns for a land-use/transport system is the key to understanding the TRANSTEP process.

Development of the Trip Length Distributions

The trip length distribution can be readily observed and calculated from existing travel patterns. The traditional four step modelling systems have long used the matching of the model generated trip length curves with the observed trip length curves as one of their key indicators for accuracy.

The trip length distributions observed are however not explanations of the travel decision but rather the observed result of the travel decision process. In particular the conceptual framework of TRANSTEP is that the observed preferred travel behaviour as expressed by trip length distribution is the joint result of two distinct and separate processes.

These two processes are firstly, the recognition of the distribution from a single point of the trip attractions or opportunities. This distribution is an expression of both land-use system and the transport system, which provides the generalised cost to the attractions. The second process operating is what has been termed the trip preference function. This indicates the individuals preference for choosing a nearer location from a further location and is independent of the land-use or transport systems. This is analogous to an economic demand function. The preference for trips decreases as the generalised cost for that trip increases.

The joint probability distribution of these two processes is the trip length probability distribution at that location. The trip length distribution is thus the joint probability distribution of finding an attraction and then, secondly, deciding to make the trip to that attraction. By separating the joint probabilities within the trip length probability distribution the independant effects of each probability distribution can be used to predict the resultant travel patterns.

The complete development of the trip length distribution is illustrated in figs. 1. to 4. and can conveniently be represented mathematically. The mathematical notation is provided in table I.

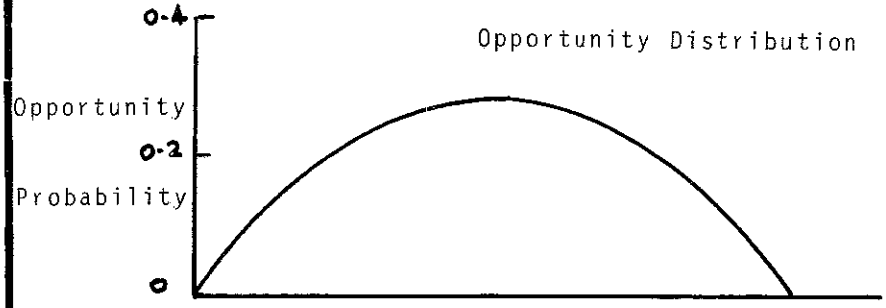
The trip attraction function can be written as:

$$A\ (S_{jp},\ L_{jp},\ N_{jp})\ \text{or}\ A_{jp}$$

and the trip production function can be written as:

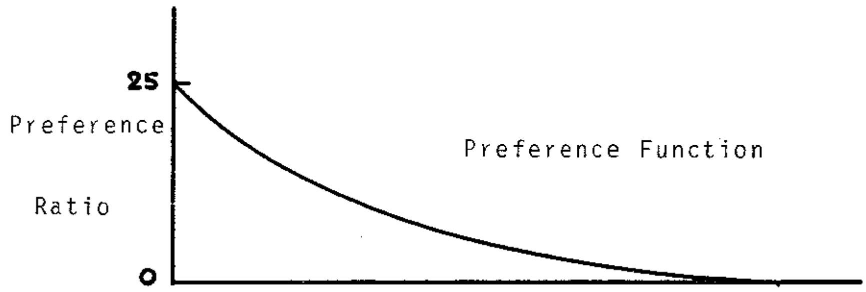
$$P\ (S_{ip},\ L_{ip},\ N_{ip})\ \text{or}\ P_{ip}.$$

where S, is a vector of social attributes
L, is a vector of physical attributes
and N is the network linkages and network level of service attributes.



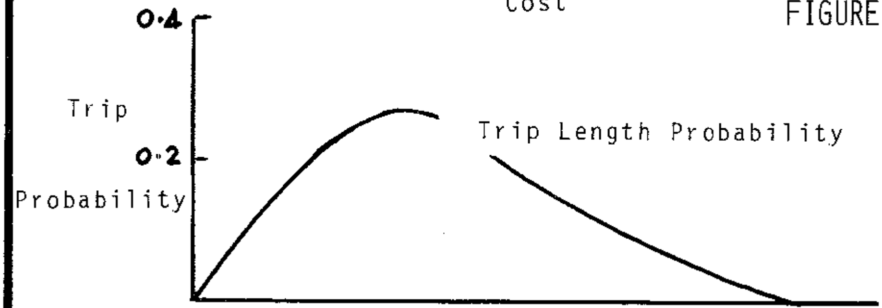
Cost

FIGURE 1



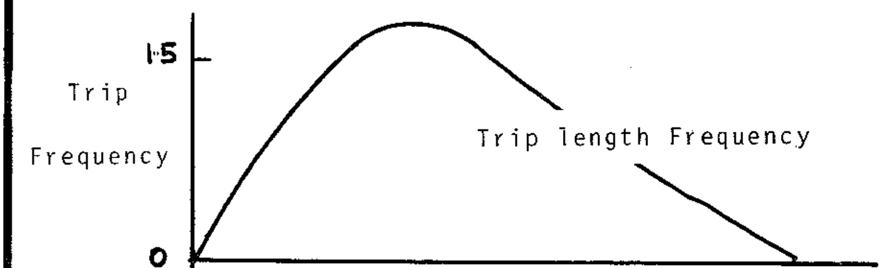
Cost

FIGURE 2



Cost

FIGURE 3



Cost

FIGURE 4

A_{jp} gives the total desired trip attractions for location j and purpose p

P_{ip} gives the total desired trip production for location i and purpose p.

The normal TRANSTEP procedure is to relate both A_i and P_i to the average trip length for that i location. Thus TRANSTEP explicitly includes the ability to vary trips for network level of service measures.

The trip attraction frequency distribution can be expressed as:

$$O_{ip}(C_{ij}) = \sum_{j=1}^{n} A_{jp}(C_{ij})$$

where C_{ij} is the generalised cost between location i and location j (1)

The sum of this distribution over the cost range:

$$\sum_{C_{ij}=0}^{C_{max}} O_{ip}(C_{ij}) = \sum_{j=1}^{n} A_{jp}(C_{ij})$$

$$= a$$

where a is the total trip opportunities for the system.

The trip attraction probability distribution can be expressed as:

$$\hat{O}_{ip}(C_{ij}) = \frac{O_{ip}(C_{ij})}{a}$$

The trip preference function is written as:

$$H(C_{ij})$$

The trip length probability function for a location i is now the normalised product of these two functions. The normalisation ensures that the probabilities add up to unity and the normalising factor is directly interpreted as an accessibility index for that zone. (1)

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(1) See Appendix 1 for discussion.

Normalising gives:

$$\sum_{C_{ij}=0}^{C_{max}} \{H(C_{ij}) \sum_{j=1}^{n} \hat{O}_{ip}(C_{ij})\} = b_i$$

Thus giving the trip length probability distribution:

$$F_{ip}(C_{ij}) = \frac{H(C_{ij})\ O_{ip}\ (C_{ij})}{ab_i}$$

The normalising factors ab_i give a direct measure of accessibility of location i. (2)

The trip length frequency distribution is then given by:

$$T_{ip}(C_{ij}) = F_{ip}(C_{ij}) \times P\ (S_{ip},\ L_{ip},\ N_{ip})$$

The normal form of the P function at this stage has been to use the average trip length of the i zone as an independent variable, thus P_{ip} is not independent of the F_{ip} function

The process that TRANSTEP uses to model the trip length distributions is unique. The development of the preference function was the breakthrough that allowed trip length frequency distributions to be generated for each location i and for each purpose p. The preference function can be developed for individuals or sub-groups and used to provide an aggregate distribution function. (The development of the preference function is outlined in appendix 4 together with examples of the function for various purposes). The greatest benefit from this approach is that the preference function is independent of zone structure, city size or land-use distribution. It is transferable.

Development of the Trip Distributions

The trip length frequency distributions describe the number of trips desired as generalised cost varies, in particular the potential trips which could be made from a location i to a particular location j. This potential does not take into account the competition of other j locations which may be competing for trips from i, similarly the potential does not consider the competition from other i locations for the attractions at location j. It is the function of the TRANSTEP distribution model to resolve these dual conflicts. The potential for trips ending at location j from all i locations does however indicate the overall potential of j as a desirable trip destination location.

The first step in the distribution process is to calculate the potential for each j location.

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(2) See appendix 2 for discussion.

$$E_{jp} = \sum_{i=1}^{n} T_{ip}(C_{ij})$$

where E_{jp} is the attraction potential for location j for purpose p.

The second step in the process is the generation of the trips between locations i and j, t_{ij}:

$$t_{ij} = A_{jp} \frac{T_{ip}(C_{ij})}{E_{jp}}$$

The A_{jp} trip attraction function has, as an independent variable, the average trip length (cost) from that j location to all the production locations i. This average trip length is calculated in exactly the same way that the average trip lengths were calculated for the T_{ip} functions but this time reversing the role of trip production and attraction equations. This means that the total trips generated may vary for alternative land-use and transport systems. The form of the equation implies the basic assumption of trip distribution constrained by the trip attractions. The significant factor with the equation is that the trip distribution explicitly recognises differences in land-use over all j locations and differences in all the total transport system for a single t_{ij} interchange. (3)

When the process is repeated with the role of the productions and attractions reversed, a productions potential measure is calculated which indicates the desirability of a location i for the siting of trip production activities.

$$J_{ip} = \sum_{j=1}^{n} T_{jp}(C_{ij})$$

where, in this case, T_{jp} is based on a trip production frequency distribution.

For many applications of the model the geographical plots of the E_{jp} and J_{ip} values provide the key analysis and interpretive outputs.

The final process performed by the distribution is the calculation of the network potential which derives from the difference in the calculated trip productions as calculated by the TRANSTEP distribution process and that which was calculated during the processing for trip length frequency distributions.

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(3) See appendix 3 for comparison with Gravity Model.

This residual R_{ip} is given by:

$$R_{ip} = P_{ip} - \sum_{j=1}^{n} t_{ij}$$

This residual is then used by the TRANSTEP distribution process to produce a net potential figure for the land-use transport system. The net potential N_{jp} is given by the following equations:

$$T_{ip} = R_{ip} F_{ip}(C_{ij})$$

$$N_{jp} = \sum_{i=1}^{n} T_{ip}(C_{ij})$$

The residuals and net potential plots can be used to highlight areas where net imbalances occur between trip production and attraction and as such indicate dynamic land-use/transport imbalances.

The distribution model thus creates the interzonal trip table.

Mode Split

The TRANSTEP trip table can now be manipulated by conventional mode split operations. The mode split functions may have been applied as the very first step in order to generate a consistent set of generalised cost skims in which case the application of mode split will be a trivial task. BEN-AKIVA (1973), McFADDEN (1972).

However, regardless of the exact user procedures, the application of mode split follows normal methods. In particular the application of behavioural logit splitting functions has received the most attention for use and calibration in recent applications.

In addition to splitting, trip table manipulations are carried out to convert the basic production attraction trip table into a daily or peak hour origin destination trip table for merged purposes.

Assignment

The recognition of the problem of equilibrium between network supply and travel demand has encouraged the inclusion of an equilibrium assignment package. With the co-operation of Australian Road Research Board an equilibrium assignment program has been developed which uses the method of feasible directions and guarantees an analytical equilibrium solution within the framework of a fixed demand problem. WIGAN and LUK (1976).

The total process of TRANSTEP can then be repeated using the equilibrium skims until a demand/supply equilibrium point is reached incorporating trip production, distribution, mode choice and travel path decisions.

It should be noted that, within TRANSTEP, the trip production, and trip distribution equilibrium decisions are simultaneously satisfied and only the travel path decision requires iteration. At present mode split is handled sequentially.

2.3 DEMOGRAPHIC/POPULATION DISTRIBUTOR MODEL

This model is in two parts. It calculates population increments of a region, and it distributes that increment amongst the zones using a function of accessibility and relative densities.

Demographic Model

The regional population increment is calculated using standard demographic principles. The base-year age-sex cohort is advanced in yearly increments according to age/sex-specific mortality, fertility and net migration rates, to calculate the population growth of the region as a whole.

Population Distributor Model

This model is based on the assumption that:

(a) Development of a zone consistently tends to follow a calibrated time/density curve.

(b) Where there is an excess of developable land, zones of equal initial density grow in density in proportion to their accessibility to trip attraction activities.

(c) Rezoning of rural land to residential land is controlled by statutory means, which also defines the timing of land releases and the desirable "final" density of each zone.

The time/density curve is assumed to start at time t, increase slowly at first then more rapidly until it again slows, reaching a maximum equal to the desirable "final" density and then declines slowly. The existence and calibration of this curve is discussed in Appendix 4.

Also, redevelopment can occur. The regrowth can be represented by super-imposing a new curve on the original time-density curve as time steps from one analysis year to the next.

The terms used in the following equations are described in Table II.

Let d (t) be the population Time/density function.

Possible incremental density of zone i at year t is given by:

$$I_{i,t} = d_t - d_{t-n}$$

where n is the step increment, in years.

The modified incremental density index for zone i is:

$$M_{i,t} = I_{i,t} \times A_{i,t}^{k}$$

where $A_{i,t}$ is the accessibility of zone i and k is a calibration constant and if T_t is the predicted increase in regional population over time t, the final incremental density of zone i is:

$$F_{i,t} = \frac{M_{i,t} \times T_t}{\Sigma(M_{i,t} \times a_i)}$$

where a_i is the area of zone i.

The new population of zone i becomes:

$$P_{i,t} = P_{i,o} + (F_{i,t} \times a_i)$$

2.4 EQUITY CATEGORY ANALYSIS

The TRANSTEP package provides a capability for expressing a series of output parameters either in graphical form or categorised by any relevant socio-economic indicator.

Thus zonal average mode-split, accessibility, trip generation rate, average trip length etc., can be plotted in contour form to facilitate evaluation of geographic equity.

Alternatively, if the proportion of each income class in each zone is provided, then each of these parameters can be catagorised by income class. Both the ean and tandard deviation of each parameter is calculated for each class.

An increase in mean accessibility indicates an improvement in transportation efficiency. A decrease in the standard deviation means that accessibility is more evenly distributed amongst zones - i.e. there is an improvement in geographic equity.

An increase in mean accessibility for low income groups vis-a-vis high income groups directly indicates a change in the direction of greater equity. DAVIDSON (1977).

2.5 ECONOMIC EVALUATION

User utility changes, due to a change in the land-use or transport system, including changes in consumer surplus and valued at perceived costs (generalised cost skims), can be shown to be:

$$B_{1,2} = \sum_i \sum_j (C_{1ij} + C_{2ij}) \ (t_{2ij} - t_{1ij})$$

where subscripts 1 and 2 refer to the test systems.

Real user costs, are:

$$C_{1,2} = \sum_i \sum_j (\hat{C}_{2ij}\, t_{2ij} - \hat{C}_{1ij}\, t_{1ij})$$

where $\hat{C}_{ij}$ is the generalised cost between i and j valued in real terms. NEUBURGER (1970).

The TRANSTEP economic evaluation module computes these user benefits and costs for the comparison between two test systems for each analysis year for which data is provided.

The module then interpolates the values for missing years, discounts them to year o and carries out sensitivity tests on stated discount rates.

It should be noted that any travel forecasting model which does not change zonal trip generation rates must, of necessity, fail to measure user utility changes due to generated travel. Appendix 6 discusses the manner in which approximations in travel predictions often made in practice effect the economic evaluation.

2.6 TRIP REVERSIBILITY

One measure of the efficiency of a transportation system is the ratio of trips in each direction on links in the network at say, the a.m. peak period, termed the reverse loading ratio.

The interzonal reverse loading index:

$$TRI_{ij} = TRI_{ji} = \frac{\min (t_{ij}, t_{ji})}{\max (t_{ij}, t_{ji})}$$

Then the regional reverse loading ratio is given by:

$$R = \frac{\sum_i \sum_j (TRI_{ij} \times t_{ij})}{\sum_i \sum_j t_{ij}}$$

where t_{ij} = number of trips from zone i to zone j.

3. APPLICATIONS OF TRANSTEP

3.1 INTRODUCTION

The TRANSTEP package has been used in a variety of configurations to address land-use or transportation planning problems. The purpose of this section is to briefly discuss some output interpretation issues and describe some typical use patterns.

3.2 OUTPUT INTERPRETATION

Before proceeding to describe some historical uses of TRANSTEP, it is useful to discuss a few examples of the packages outputs. Figures 5 to 8 illustrate trip generation rate, average trip length, employment potential and employment imbalance plots for either white or blue collar work purposes in Melbourne using data provided by the Victorian Joint Road Planning Group.

In interpreting the contour plots it should be borne in mind that the coarse strategic network from which they were derived had about 80 zones within the approx. area contained within the outer-most contour. This serves to delineate the accuracy with which the contours may be read.

In the employment potential and employment imbalance plots the "potential trip-end" measure has no physical or absolute significance to the planner. It is a relative measure with geographic significance shown in the contours. Similarly comparing employment imbalance as a proportion of employment potential can be a useful indicator.

The contours are surprisingly sensitive in use but, as each zone's contribution is relatively small and widespread, the response of the planner to this information need not be geographically exact to produce beneficial effects.

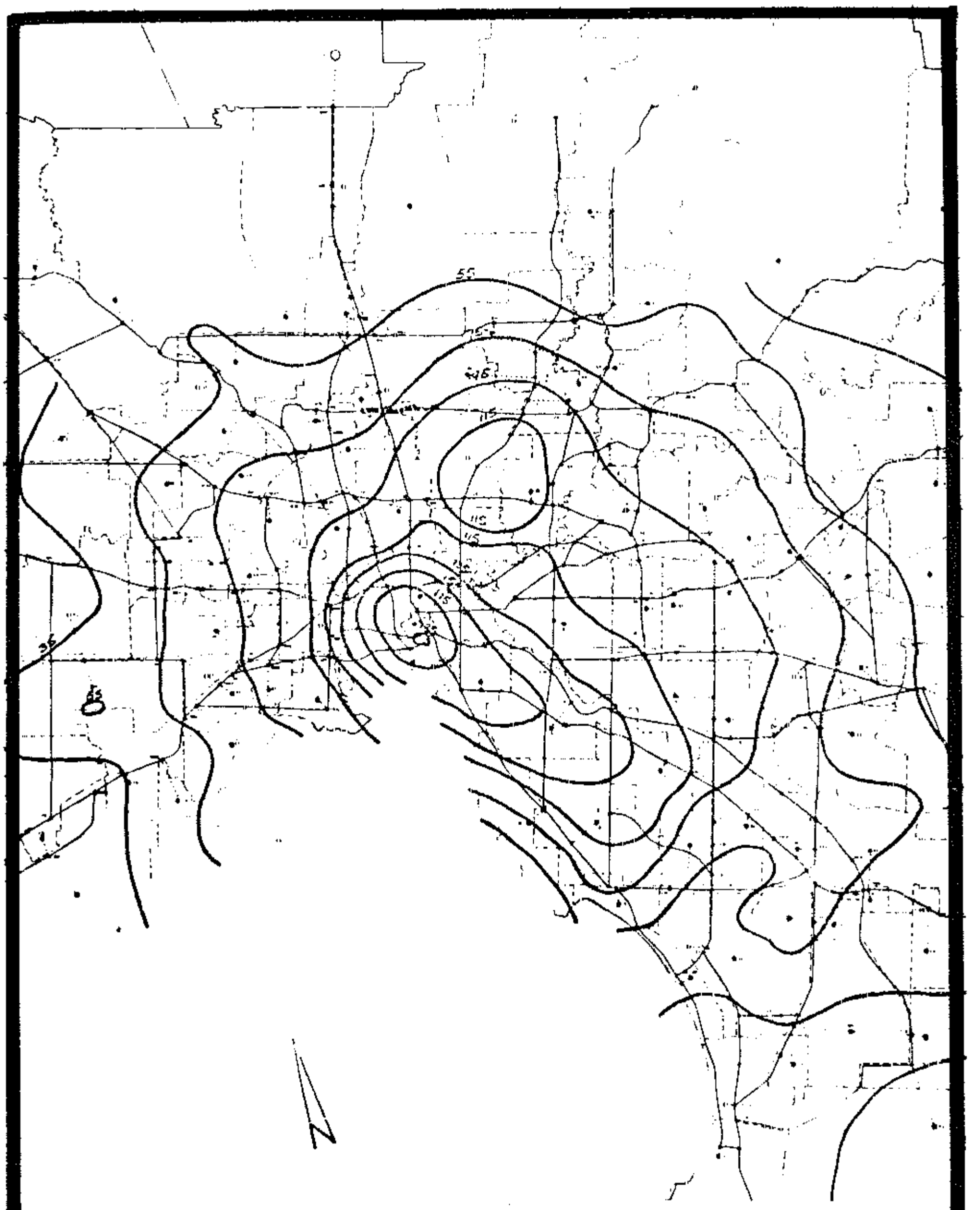
The reverse loading ratio is also a relative measure and is only transferable under very strict conditions.

The user must also define his mode of time-scale operation analagous to defining either a "stock" or "flow" operation. A "stock" operation for purpose work assumes that the entire regional workforce competes at every time for all employment opportunities. A "flow" operation, on the other hand, assumes that only new workforce entering the region may compete for new employment opportunities and that all other jobs are retained.

Clearly both assumptions are extremes, the actual behaviour lying between them. The user may wish to try both modes and a simple data update procedure is available to do this. The population distributor module, however, can only be used in incremental mode ("flow").

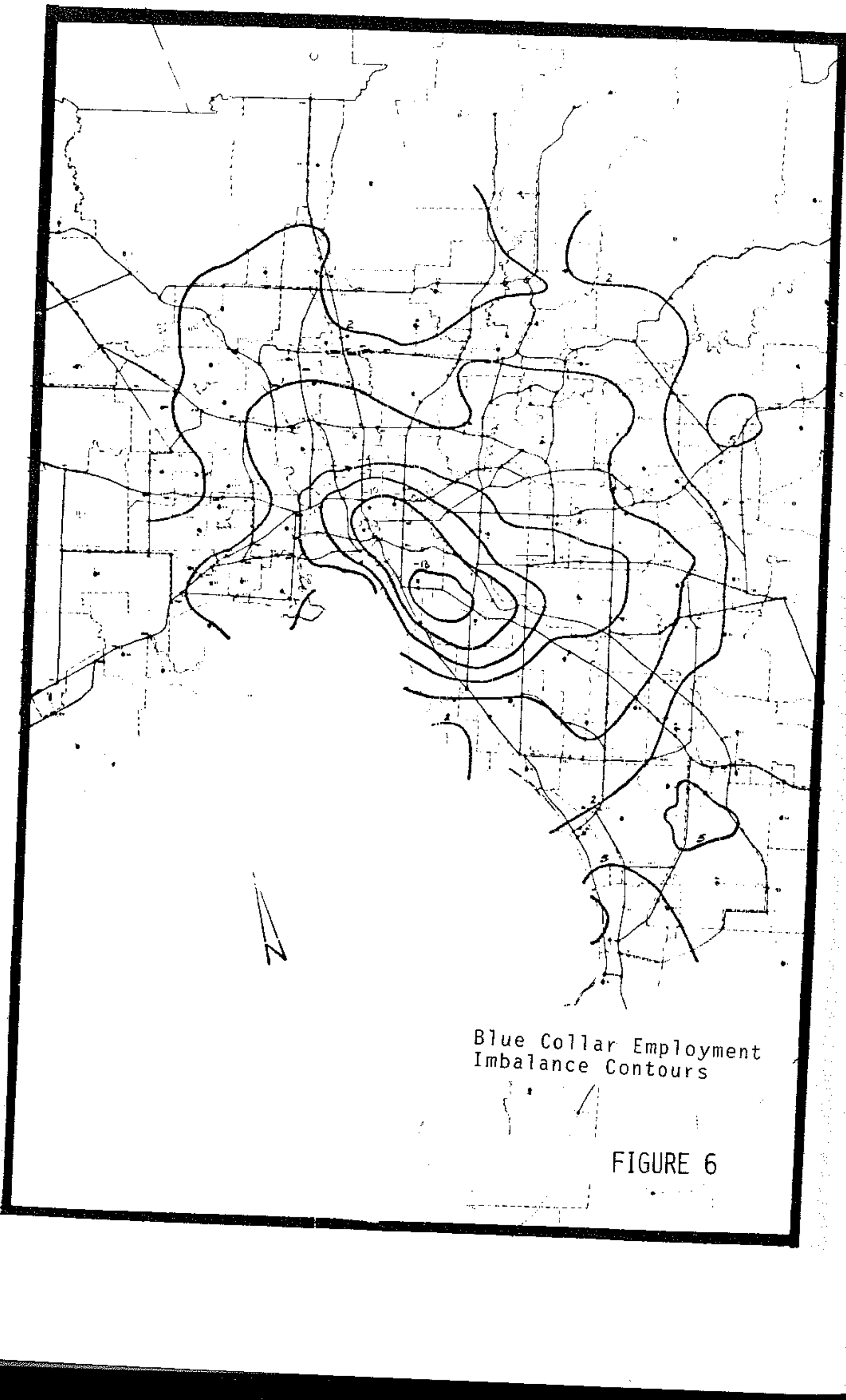
Whether the package is used in static or incremental mode the interaction between the transportation planner using the package and the land-use planner is explicit and illustrated in figure 20.

Recognition by the planner of imbalances and accessibility created in the plan for an earlier year leads to their partial resolution in the release of new residential land, which in turn is analysed to permit the planner to influence the location of new employment or retailing. Analysis of this plan provides the imbalance and accessibility information for the next time step.



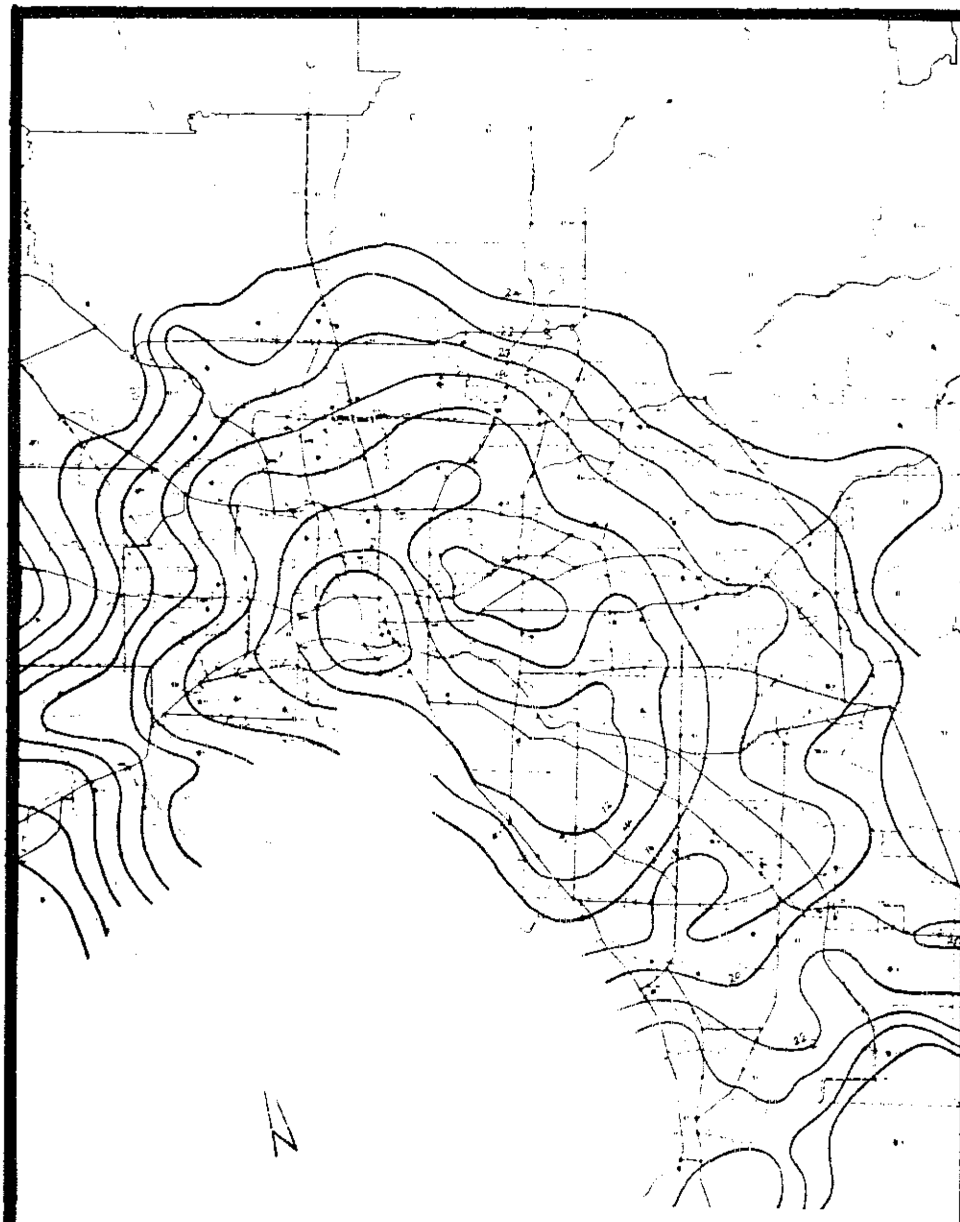
Blue Collar Employment
Location Potential Contours

FIGURE 5



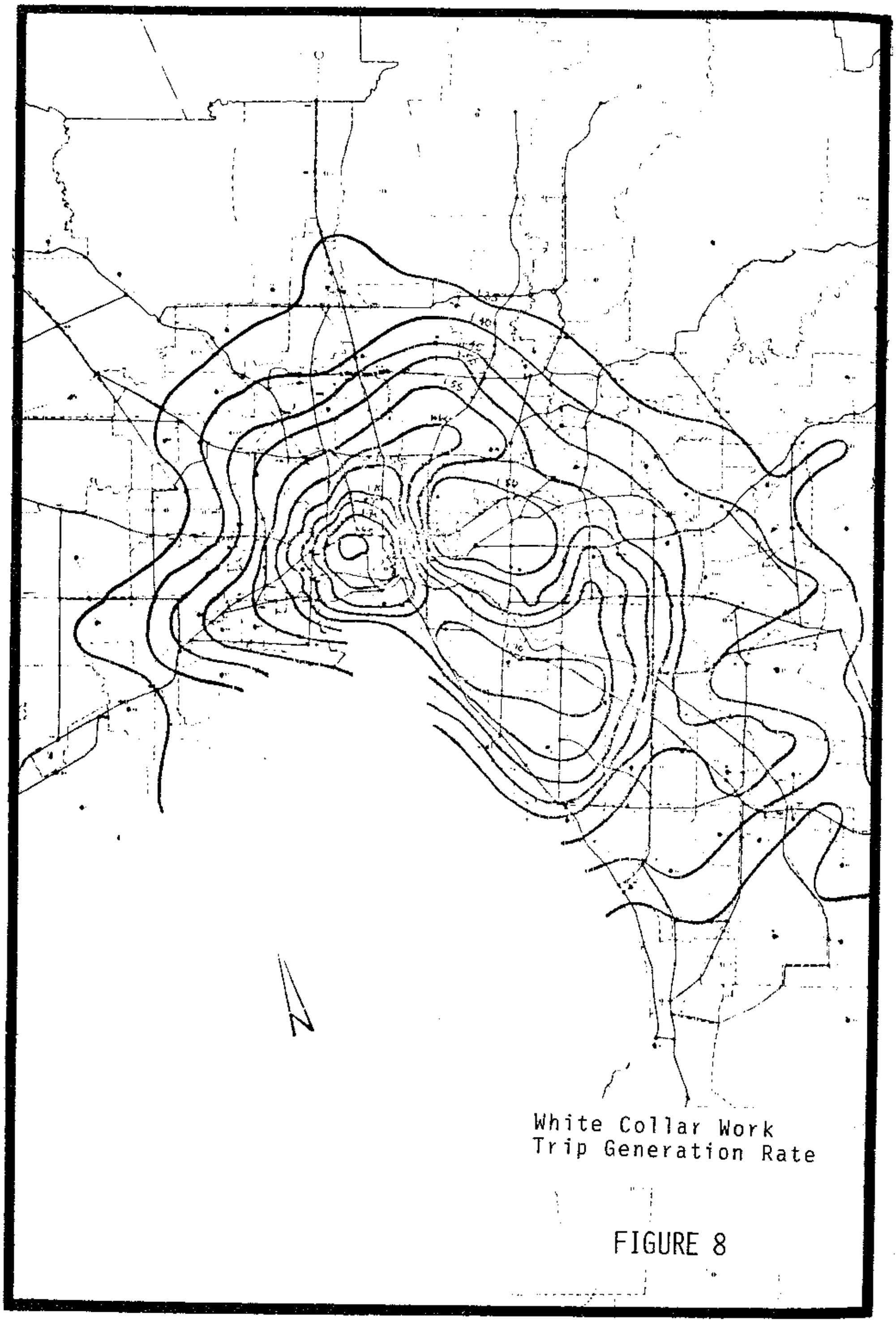
Blue Collar Employment Imbalance Contours

FIGURE 6



White Collar Average
Work Trip Duration

FIGURE 7



White Collar Work
Trip Generation Rate

FIGURE 8

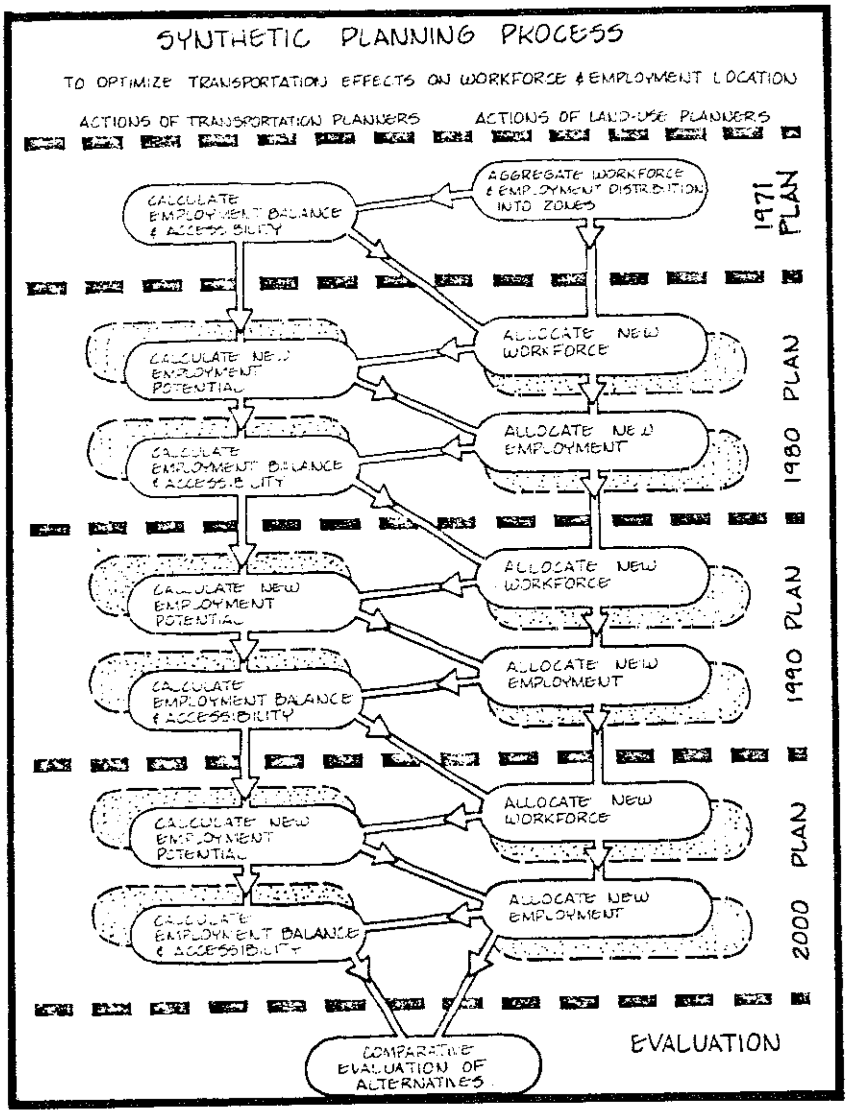

SYNTHETIC PLANNING PROCESS
TO OPTIMIZE TRANSPORTATION EFFECTS ON WORKFORCE & EMPLOYMENT LOCATION
ACTIONS OF TRANSPORTATION PLANNERS
ACTIONS OF LAND-USE PLANNERS
AGGREGATE WORKFORCE & EMPLOYMENT DISTRIBUTION INTO ZONES
CALCULATE EMPLOYMENT BALANCE & ACCESSIBILITY
1971 PLAN
ALLOCATE NEW WORKFORCE
CALCULATE NEW EMPLOYMENT POTENTIAL
ALLOCATE NEW EMPLOYMENT
CALCULATE EMPLOYMENT BALANCE & ACCESSIBILITY
1980 PLAN
ALLOCATE NEW WORKFORCE
CALCULATE NEW EMPLOYMENT POTENTIAL
ALLOCATE NEW EMPLOYMENT
CALCULATE EMPLOYMENT BALANCE & ACCESSIBILITY
1990 PLAN
ALLOCATE NEW WORKFORCE
CALCULATE NEW EMPLOYMENT POTENTIAL
ALLOCATE NEW EMPLOYMENT
CALCULATE EMPLOYMENT BALANCE & ACCESSIBILITY
2000 PLAN
COMPARATIVE EVALUATION OF ALTERNATIVES
EVALUATION

FIGURE 20.

3.3 STRUCTURE PLAN SYNTHESIS AND EVALUATION

The earliest use of the TRANSTEP/package was in the sequential planning and evaluation of options for the year 2000 structure plan for the Albury-Wodonga Growth Centre. The package in this application was used in a static mode to provide the transportation planners input into the synthesis and selection of the structure plan in two basic stages. DE LEUW, CATHER (1974).

After initial pre-selection, seven different concepts for development of the Growth Centre were tested. They varied from compact city concepts, twin city concepts, scattered town concepts to a linear city concept.

Transportation efficiency was addressed through reverse-loading-ratio criterion and the concentration of travel desire lines into patterns which suited terrain, environment and engineering constraints on the planning of the transportation network.

Travel efficiency was also addressed by evaluating the incidence of employment imbalance, which would lead to excess travel times to work. The plots of these imbalances were used sequentially by the planners to refine the structure plan as it progressed into a refinement stage.

During this more detailed stage, as the transportation network became more defined, the model was used with network rather than airline skims, several travel purposes were introduced and network assignments were used to refine the location and need for major elements of the transportation system. Economic evaluation was used to further assess the staging and merit of major facilities in the system such as the River Murray crossings.

The resultant structure plan was of a curved but linear concept. The predicted loadings on major transport facilities had excellent two-way characteristics and the pattern of urban centres provided the best compromise between accessibility and public transport useage motives.

3.4 TRANSPORTATION FACILITY IMPACT EVALUATION

There have been two major applications of the TRANSTEP package in evaluating transportation facility impacts on a "with and without" basis.

The most recent application refers to the impact of a major peripheral freeway in one of Australia's largest cities. Unfortunately, as the official report of this application has not yet been made public it is not possible to refer directly to the results.

TRANSTEP was run for test conditions with and without the entire length of freeway for the purpose of white-collar work.

The results showed that trip generation rates, the indicator of participation in urban activities, increased most in zones nearest to the freeway and in zones which, in the "without" case, had least trip generation rates. This impact was, therefore, an equitable one.

The results also showed that average trip duration for zones outside the circumference of the freeway, all fell and, as these zones had the largest trip duration, this impact was also an equitable and efficient one.

The impacts of improvement in the ability to attract employment favoured outer zones and, therefore, promoted an urban sub-regionalisation process. Further the ability to redress employment imbalance favoured some zones where employment imbalance was high although there were some zones with reverse effects.

The results also showed those areas where pressures for further population increase would accelerate as a result of the freeway implementation.

The equity category analysis module showed that there was some tendency to reduce the pronounced inequity in the distribution of accessibility to white-collar work opportunities which favoured high-income groups. Further there was a tendency for the distribution of accessibility on a geographic basis to become more even between zones.

An earlier application, during the Parramatta Region Public Transport Study, involved the use of the TRANSTEP package in a different configuration. The problem was to describe the longer term impacts of the development of three major corridors supplementing the existing three radiating from the Parramatta City Centre. DE LEUW, CATHER (1976).

The TRANSTEP population distributor model was used, in an incremental mode, to predict increases in population in the region due to the proposed increases in public transport accessibility. The impacts on regional mode split, trip generation and trip distribution patterns were also evaluated both with and without the attendant population increase so that the relative magnitude of both these direct and indirect effects on the travel pattern could be assessed.

3.5 LAND-USE IMPACT EVALUATION

The package is also suitable for the assessment of impact effects where there is no change at all to the transportation system (including congestion effects) but where the change is purely a land-use one.

For instance, suppose a large new University is to be placed in a suburban area which is predominately residential. The TRANSTEP package can be used to predict the following impact effects:

(a) The increase in traffic volumes in the area due to the expected enrolment or workforce.

(b) The increase in employment/educational opportunities and employment/educational accessibility in the zones in the region.

(c) The increase in expected enrolments or workforce participation due to (b) above.

(d) The increase in traffic volumes due to (c) above.

3.6 SYNTHESIS AND EVALUATION OF LAND-USE GROWTH PATHS

The most extensive application of the TRANSTEP package has been its use in the synthesis and evaluation of alternative land-use growth paths, according to alternative growth strategies, in the review of the Canberra structure plan, the report of which is in the process of publication. N.C.D.C. (1977).

In this application the graphic outputs of production and attraction activity potentials and imbalances were used at a series of time periods along the growth paths of alternative strategies. They indicated the degree to which government planning initiatives would be supportive of, or in conflict with, predicted market plans for the expansion of employment or retailing in various parts of Canberra in future years.

TRANSTEP clearly pointed out the problems and benefits of attempting to create employment and retailing activity in newly growing development areas. It became clear when these problems would ease and enabled the construction of a meaningful development scenario for each alternative growth strategy.

The package was also used to provide the economic evaluation of each of the alternative growth paths.

4. TRANSTEP PACKAGE SUPPORT FEATURES

4.1 INTRODUCTION

This section discusses some of the user features of TRANSTEP. A long-term goal in the program design has been to aim towards eventual on-line interactive use. This objective has conditioned some aspects of the approach to data specification, updating and the scope of the separable modules.

Presently TRANSTEP is operating on the CDC CYBERNET system (scope 3.4) and the CSIRO NET system (scope 2.1). It uses certain aspects of these machines to advantage, making it cost-effective and easy to use.

In a typical application with 150 zones an execution of TRANSTEP, including a land-use update, trip distribution and assignment, with the associated evaluative calculations, but excluding plotting, costs approx. $15 on CSIRONET at Commonwealth Department rates.

This low cost, and the fast turnaround means that planners are seldom limited by the computer in their ability to analyse a large number of alternative stategies in a few weeks.

Data specification is facilitated if a package is designed to be suitably consistant with user attitudes to the relative importance of various aspects of the data and the modelling process. The following package support features are, therefore, discussed in the context of suggested user attitudes.

4.2 UPDATE LAND-USE

The land-use file permits the user to hold up to five production or attraction land-use parameters so that mixed purpose applications are possible or, to run another purpose, the user simply specifies the fields for another set of production parameters. The limit of five parameters only arises through a desire to contain all of the zonal land-use information on one card.

This feature enables the user, if desired, to specify a complete matrix of purpose-to/purpose-from passes, eliminating the need for the vaguely specified non-home-based purpose usually used as a catchall in conventional forecasting procedures. The improved accuracy of prediction inherent in this feature, in the authors' opinion, outweighs the loss of accuracy due to the loss of ability to specify minor trip purposes within the scope provided by five production or attraction parameters. It also means a savings in data specification when compared with conventional practises.

Application of TRANSTEP permits the same parameter to be specified for both production and attraction activities in conjunction with other parameters. A typical example could be to specify a single pass to predict trips for the following purposes:

(a) Home Based - Shopping

(b) Work Based - Shopping, and

(c) Shop Based - Shopping (including intrazonals)

Thus, in the extreme, an entire purpose-to/purpose-from trip matrix can conveniently be predicted in a single TRANSTEP pass.

TRANSTEP also permits the compression of the land-use file, for certain purposes, from the normal 80-200 zones to, say, 20 zones. This is useful for printing out an abbreviated trip table in order to plot desire lines. It is necessary for the production of the reverse loading ratio parameter, which is dependant on the number of zones and this must be specified for any TRANSTEP application involving comparisons.

Another feature which is particularly convenient when TRANSTEP is being applied in several time periods, is the ability to add new zones to the land-use file.

There are four ways of updating as follows:

(a) Add new zones

(b) Delete zones

(c) Change a zonal parameter by increment or replacement

(d) Change parameters on a macro-scale

The module also checks and sorts the data.

4.3 COMPUTE AIR DISTANCES

TRANSTEP normally uses a generalised cost skim file obtained from networks, but it is possible to use straight-line distances between the zone centroids, rectilinear distances, or a combination of the two. This is sometimes useful for new-town developments where, in the early stages of planning, no network alternatives have been devised.

4.4 TRANSPOSE MATRIX

The TRANSTEP distribution model produces a production/attraction trip table and its transpose, but this utility program is sometimes useful for transposing matrices from other sources.

4.5 MODE SPLIT OPTIONS

There are two mode choice models available in TRANSTEP. Both models write a multi-purpose trip matrix with some or all of the following tables:

(1) Total person trips
(2) Car person trips
(3) Car vehicle trips
(4) Public transport person trips
(5) Bus person trips
(6) Corridor mode (e.g. train) person trips
(7) Bus vehicle trips
(8) Total vehicle trips

The first option is intended for use with very simple networks, where no transit network is provided and gives a crude mode split, which depends mainly on the density of attraction activities. This option should be used in new-town strategy evaluation problems.

Transit trips are given by:

$$t_{ijm1} = \{(k_1 + k_2 \times A_j)\ C_{ij} + k_3\}\ t_{ij}$$

where t_{ijm1} = transit trips from i to j and k_1, k_2, k_3 are calibration coefficients.

Transit trips are further split into corridor mode and tram/bus person trips.

$$t_{ijm3} = \{(k_4 + K_5 \times A_j)\ C_{ij} + k_6\}\ T_{ij}$$

t_{ijm3} = corridor mode person trips from i to j and k_4, k_5, k_6, are calibration constants.

The second mode choice option is based on the standard logit formulation:

$$P_i = \frac{e^{u_i}}{\sum_j e^{uj}}$$

where P_i = probability of using mode i

u_i = a linear function of independant variables.

The split into car, rail and tram/bus can be done as a series of successive binary splits, or each mode can be calculated as a proportion of total person trips.

4.6 FORMAT CONVERSION

Skims, trip tables and networks are in standard TRANPLAN format. Routines are readily available to convert these for any of the other major transportation planning packages such as FHWA and UTPS, as TRANSTEP is sometimes used in conjunction with them.

5. CONCLUSION

This paper has introduced the land-use/transport interactive planning package TRANSTEP. It has outlined the needs from which the TRANSTEP package developed, the objectives of the model development, the conceptual framework of the various functions within the TRANSTEP package, tha manner in which the package has been used and some of the user-oriented attributes.

The explanation of the travel activities model illustrates several areas where new conceptual ground has been broken and presented the research undertaken to date in these areas. This research has validated the overall functional relationships which make up the TRANSTEP modelling process. It has been undertaken totally within a consultancy framework where both manpower and time resources for unfunded research are extremely limited and, in some areas, continuation of this basic research is needed.

Comparisons between features of the TRANSTEP package and conventional processes have been highlighted. This has illustrated the important differences between thw two and at the same time shown how TRANSTEP has developed within a familiar framework which should facilitate training.

The package adds features, which have previously been lacking from the planners tool kit, but sacrifices very little in the process. Because it is inexpensive in operation, easy to learn, requires little data and is transferable between problems with little or no calibration, it enables a rapid response to policy planning and strategic planning questions.

The emphasis placed on the production of visual plotted output and category analysis greatly enhances the planner's ability to discuss equity or distributional aspects of a problem, but care is needed in the interpretation of these outputs.

In particular there is a tendency for users to interpret the TRANSTEP outputs simply in conventional transport modelling terms rather than in the fuller scope of the complete TRANSTEP modelling process.

TRANSTEP is fully operational at present but the authors see ample scope for further conceptual and operational research and development to improve the practical performance and scope of the package against the stated objectives.

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TABLE I NOTATION: TRAVEL ACTIVITIES MODEL

SYMBOL	DEFINITION
i	Production zone or location index
j	Attraction zone or location index
p	Purpose index
m	Mode index
$m1$	Transit mode
$m2$	Highway mode
$m3$	Corridor transit mode
C_{ij}	The generalised cost between i and j
t_{ij}	Trips between locations i and j
S	A vector of social attributes for all locations
L	A vector of physical attributes for all locations
N	The network linkages and level of service attributes
S_{ip}, L_{ip}, N_{ip},	The attributes particular to location i & purpose p
$A(S,L,N)$	The trip attraction function for the system
A_{jp}	The trip attraction for location j, purpose p
$P(S,L,N)$	The trip production function for the system
P_{ip}	The trip production for location i, purpose p
$O_{ip}(C_{ij})$	The trip attraction frequency distribution
$\hat{O}_{ip}(C_{ij})$	The trip attraction probability distribution
a	The total attraction for the system
$H(C_{ij})$	The trip preference function
$F_{ip}(C_{ij})$	The trip length frequency distribution for location i, and purpose p
$T_{ip}(C_{ij})$	The trip length probability distribution for location i, and purpose p
b_i	The normalising factor for the trip length frequency distribution at location i
E_{jp}	The attraction potential at location j
J_{ip}	The production potential at location i
R_{ip}	The residual production at location i
N_{jp}	The net potential at location j
P_{ijm1}	The probability of mode m1 between i and j
C_{ijm1}	The generalised cost of mode m1 between i and j
$f(C_{ij})$	The Gravity Model friction factor function.

TABLE 2 NOTATION: DEMOGRAPHIC MODEL

T_t	Total regional population increment over time t
t	Time period relative to same base year
$d(t)$	Population density growth function
$I_{i,t}$	Incremental density of zone i in year t
$M_{i,t}$	Modified incremental density of zone i at year t
$A_{i,t}$	A measure of trip accessibility at zone i in year t
$D_{i,t}$	Density of the zone i in year t
$P_{i,t}$	Population at zone i in year t.

APPENDIX 1 - GENERALISED COST

Thê generalised cost concept has long been a part of transport modelling. Generalised cost can include a range of attributes for a range of modes and travel variables. McINTOSH (1970).

The analyst must be careful when including multiple modes into a generalised cost formula so that the specification of a net generalised cost is consistent with the generalised cost used in the mode split functions. For instance if only time and distance are considered, the introduction of a public transport service between a zone pair often increases the generalised cost between those zones compared to a highway only alternative.

However if the same cost is used throughout the modelling process this problem will not arise. For instance consider a logit mode split model:

$$P_{ijm1} = \frac{e^{-C_{ijm1}}}{e^{-C_{ijm1}} + e^{-C_{ijm2}}}$$

$$P_{ijm2} = \frac{e^{-C_{ijm2}}}{e^{-C_{ijm1}} + e^{-C_{ijm2}}}$$

and $P_{ijm1} + P_{ijm2} = 1$

where P_{ijm1} is the probability of transit choice between location i and j ; P_{ijm2} is the highway probability, and C_{ijm1} is the transit cost attributes.

Then a fully consistant choice for generalised cost would be:

$$C_{ij} = P_{ijm1}C_{ijm1} + P_{ijm2}C_{ijm2}$$

APPENDIX 2 - ACCESSIBILITY

During the development of the trip length probability distribution a pair of normalising factors emerge. These ab_i factors have an evaluative significance.

The ab_i factor is analogous to a traditional measure of accessibility which has long been used, and that is :

$$\text{accessibility of } i = \sum_j \frac{A_j}{C_{ij}^{\Theta}} \qquad \text{(HANSEN 1959).}$$

where θ is some specified factor (commonly the denominator has been time squared) and A_j is the trip attractions at j.

The ab_i factor has an identical structure:

$$ab_i = \sum_{C_{ij}} \{H(C_{ij}) \sum_j A_j(C_{ij})\}$$

and if the preference function could be expressed as:

$$H(C_{ij}) = \frac{1}{C_{ij}{}^{\theta}}$$

$$\text{then } ab_i = \sum_{j=1}^{n} \frac{A_j(C_{ij})}{C_{ij}{}^{\theta}}$$

Thus the ab_i factor can be directly interpreted as a relative accessibility measure for a particular zone, and is based on an observed behavioural preference function.

APPENDIX 3 - COMPARISON WITH GRAVITY MODEL

It is interesting to compare the TRANSTEP distribution with the conventional gravity model trip distribution to see the differences and similarities. Consider the singly constrained gravity model:

$$t_{ij} = A_j \frac{P_i f(C_{ij})}{\sum_{k=1}^{n} P_k f(C_{kj})} \quad \text{(F.H.W.A. 1974)}$$

where A_j and P_i are respectively, the production and attractions and $f(C_{ij})$ is the friction factor function for the i to j interchange.

The TRANSTEP model is:

$$t_{ij} = A_j \frac{T_i(C_{ij})}{\sum_{k=1}^{n} T_k(C_{kj})}$$

where A_j is trip attractions and $T_i(C_{ij})$ is the trip length frequency distribution. Rewriting the TRANSTEP model gives:

$$t_{ij} = A_j \frac{P_i F_i(C_{ij})}{\sum_k P_k F_k(C_{kj})}$$

$$t_{ij} = \frac{\{A_j P_i H(C_{ij})\ O_i(C_{ij})\} \div ab_i}{\sum_k \{P_k H(C_{kj})\ O_k(C_{kj}) \ \div ab_k\}}$$

if the two models are to be equivalent then the following identity must hold:

$$\frac{\{H(C_{ij})\ O_i(C_{ij})\} \div ab_i}{\sum_k \{P_k H(C_{kj})\ O_k(C_{kj})\} \div ab_k} = \frac{f(C_{ij})}{\sum_k P_k f(C_{kj})}$$

Examination of this identity reveals some important properties of the two formulations. The Gravity Model friction factor function $f(C_{ij})$ does not include any factor which explicitly includes the land-use /transportation distribution effects acting on any location i. The friction factor function when calibrated implicitly takes into account the base year land-use/transport system, but for future land-uses the same frictions would not apply. The huge range of different friction functions reported in FHWA (1974) illustrates the specific nature of friction factor functions for a particular city and time.

The TRANSTEP distribution model, however, specifically takes into account the land-use/transport system changes via the

$\frac{O_i(C_{ij})}{ab_i}$ function, which furthermore is specific to each zone. One could consider this term as representing the competition from different destination locations for attracting trips from location i while the denominator could be viewed as representing the competition from other origin locations competing with the attractions at location j.

The only way in which the Gravity Model and TRANSTEP distribution would be identical is for the attraction probability distribution to be identical for all zones i and for:

$$\frac{H(C_{ij})\ O_i\ (C_{ij})}{ab_i} = f(C_{ij})$$

where $\frac{O_i(C_{ij})}{b_i}$ is invariant for all zones.

However $f(C_{ij})$ is calibrated for a base year situation, is invariant for zone i and is assumed to be invariant for future years. But the TRANSTEP function contains two parts. One is the

$H(C_{ij})$ function which is invariant from base year to future years, but the other $O_i(C_{ij})$, however, is dependent on the land-use/transportation system and is unique for each zone i. Thus while the Gravity Model may be valid to describe base years it is not valid if the land-use distribution changes, since the friction factor function is dependent on the base year land-use. The TRANSTEP distribution model however is sensitive to changes in land-use and is in no way related to base year conditions except in the derivation of the preference function, which to date appears to be invariant across cities and time.

APPENDIX 4 - MODEL TESTING AND VALIDATION

INTRODUCTION

This appendix sets out some of the validation tests to which the calibration functions and modules were subjected during their development.

1.1 THE PREFERENCE FUNCTION

The essence of value of the TRANSTEP distribution process, is contained in confidence that the preference function exists in a statistical sense, is stable geographically and can be derived from conventional data. It is also of value to know how it behaves under category analysis.

The preference function is derived by dividing the ordinates of observed zonal trip length probability functions by the ordinates of the zonal opportunity function.

The zonal trip length probability function is obtained from survey trip tables and interzonal skim tables. The opportunity function is obtained within TRANSTEP from the land-use information and inter-zonal skim tables. The derivation of the preference function, therefore, uses easily obtainable conventional data.

The existence of the preference function was first tested using data from the Sydney Area Transportation Study base year files. The preference function was a smooth curve with a monotonic decrease with time. The normal deviate was reasonably constant except for times in excess of 60 minutes and confidence levels were approximately 95%.

The Sydney preference functions were then used in TRANSTEP and compared against data from the Canberra Short Term Transportation Study base year files. The results of this comparison are shown in figures 9 and 10 and indicate that the preference function is reasonably stable geographically.

The preference functions were derived for four different trip purpose categories using the Sydney data, namely:

(a) Home Based - Non Manufacturing Work

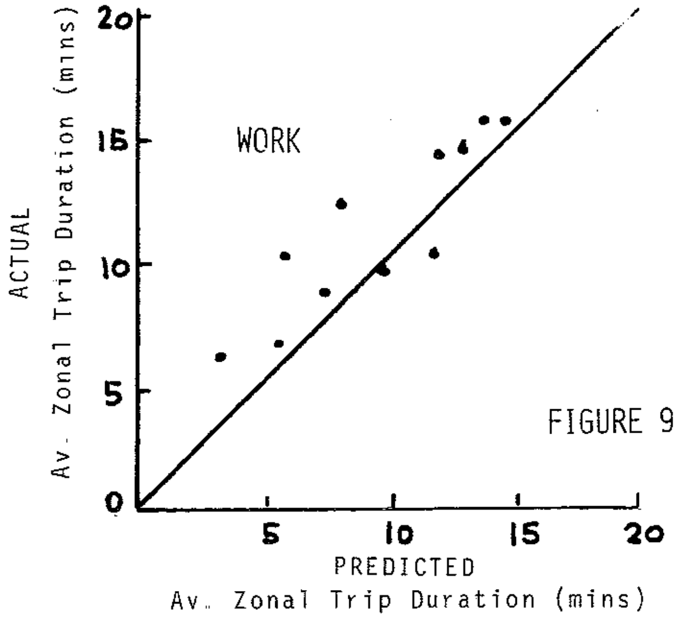


FIGURE 9

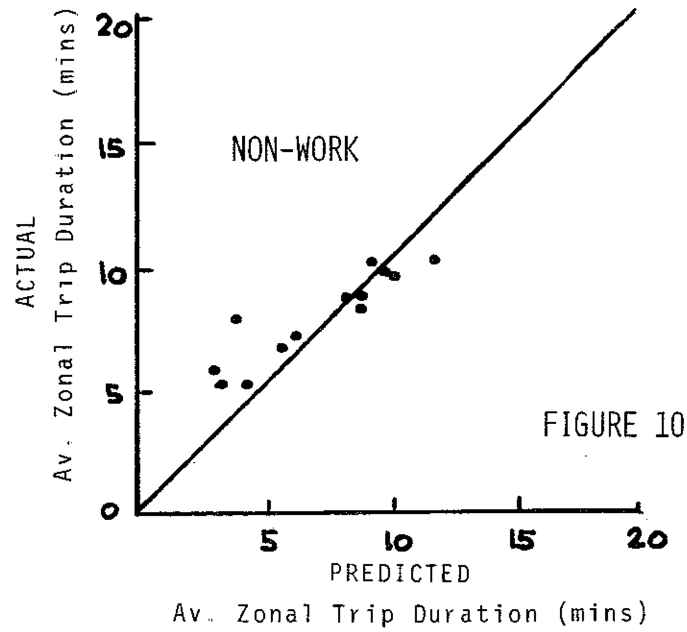


FIGURE 10

Source: Canberra Structure Plan Review
Canberra Short Term Transportation Planning Study

(b) Home Based - Manufacturing Work
(c) Home Based - Shopping
(d) Home Based - Personal Business

These curves are shown in figure 11. The two work curves were generally so similar that they could not be separated statistically. The Work, Shopping and Personal Business curves were, however, statistically discrete.

The curves do illustrate that individuals preference functions vary significantly with trip purpose. In particular the work curves indicate a relative indifference to travel when compared to the Shop or Personal Business curves. This conforms with preconceived notions of how travel decisions are made and further reinforced confidence in the preference function. Another way of expressing these differences would be to say that the demand elasticity for travel is far greater for Shopping and Personal Business than for work, and that the elasticity varies throughout the travel "cost" range, such that the elasticity is greatest for changes for short trips, becoming smaller as trip length increases until the elasticity is virtually zero for trips longer than seventy to eighty minutes.

In summary, the authors have confidence in the existence and stability of the preference function and have, as occasion permits, begun to investigate its behaviour by category analysis Much more research needs to be carried out to fully substantiate this work, which has not been conducted under ideal research conditions.

1.2 THE TRIP LENGTH FREQUENCY MODULE

The next step in validation was the testing of the predictive value of the trip length frequency module. To test its power to reproduce the data from which it was derived was a simple first exercise. Comparison between the predicted and actual L.G.A. trip length probability distributions for Sydney are shown in figures 12 to 14.

The module's power to predict Canberra's zonal trip length probability distribution function is shown in figures 9 and 10.

A more general testing also illustrated the power of the module to logically predict the following observed variations in trip length frequency functions:

(a) Trip length frequency functions skew to the right as city size increases. Vide figure 15.

(b) Trip length frequency functions skew to the right as distance from a CBD increases within a conurbation. Vide fig. 16.

(c) Trip length frequency functions skew to the right as the ratio of zonal employment opportunities to zonal workforce decreases. Vide Fig. 17.

1.3 THE TRIP GENERATION FUNCTION

The relationship between average zonal trip generation rate and

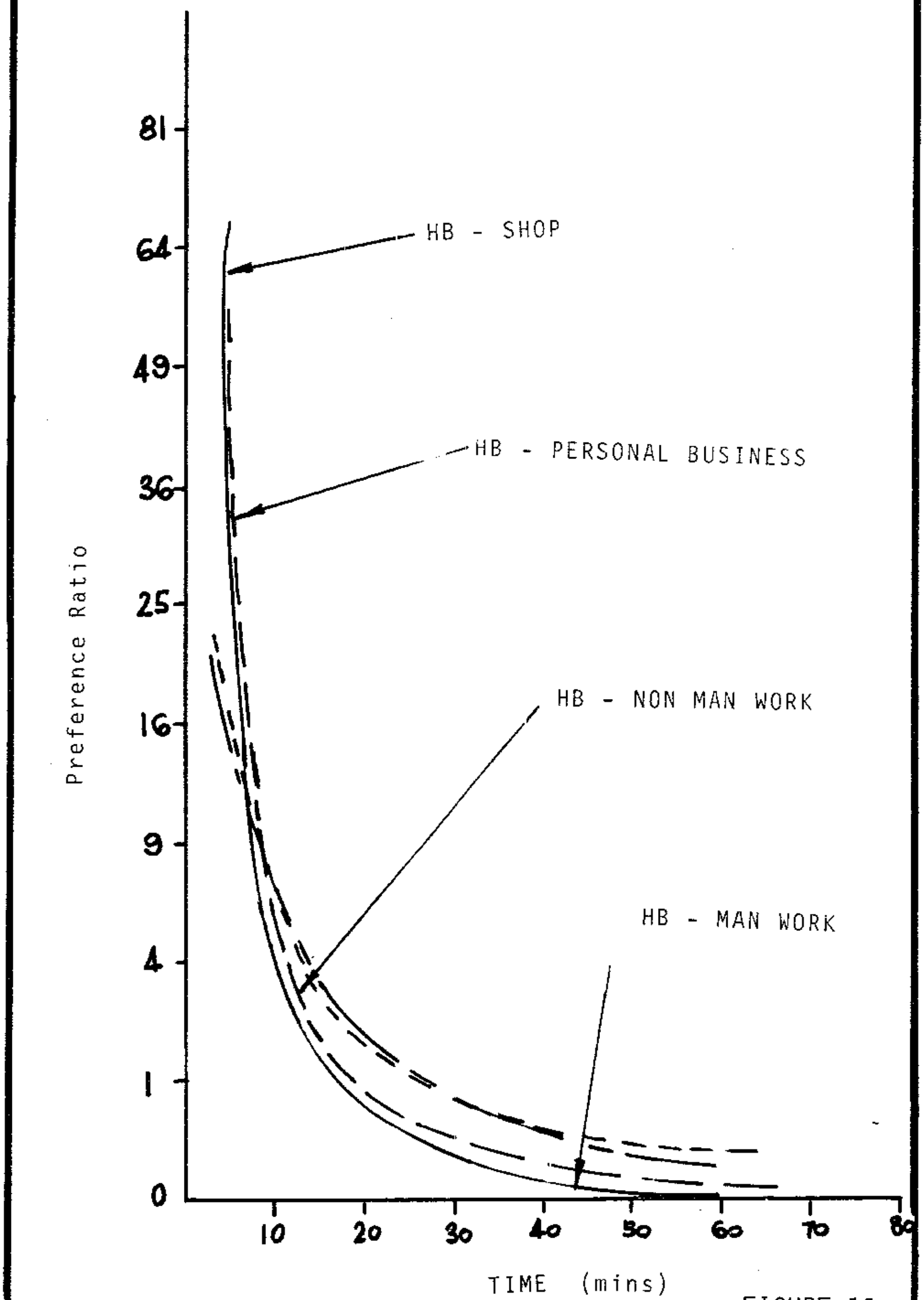
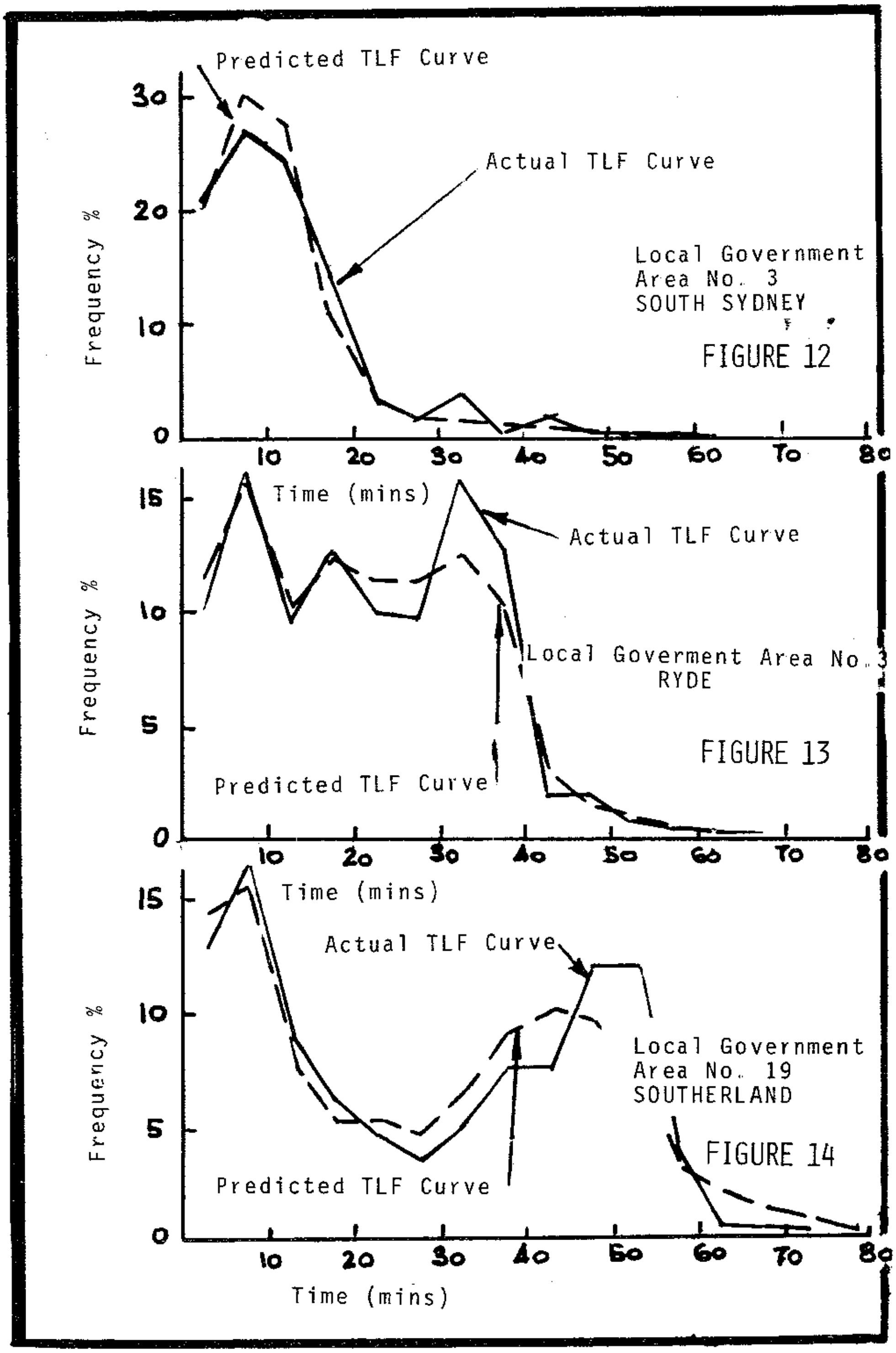

81
64
49
36
25
16
9
4
1
0
Preference Ratio
HB - SHOP
HB - PERSONAL BUSINESS
HB - NON MAN WORK
HB - MAN WORK
10
20
30
40
50
60
70
80
TIME (mins)

FIGURE 11



Source: Sydney Area Transportation study

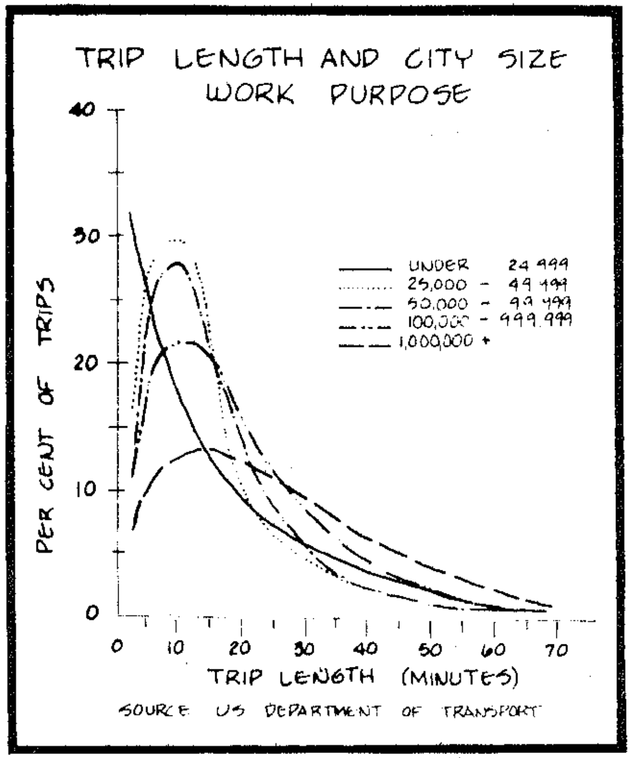


FIGURE 15

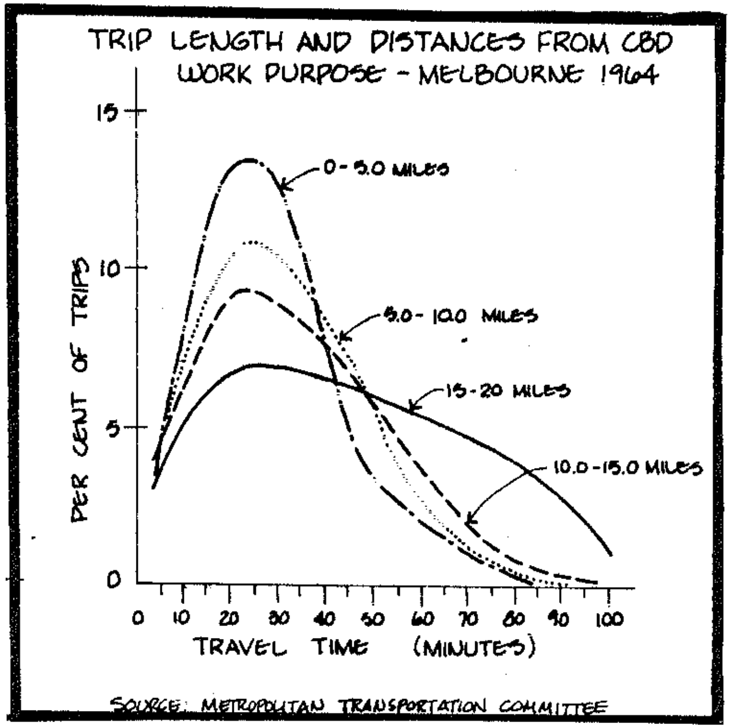


FIGURE 16

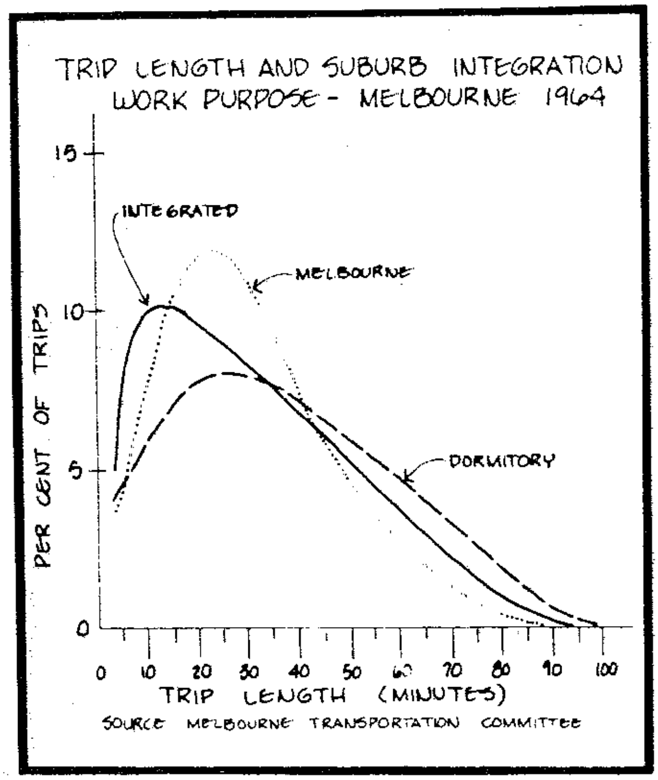

TRIP LENGTH AND SUBURB INTEGRATION
WORK PURPOSE - MELBOURNE 1964
INTEGRATED
MELBOURNE
DORMITORY
PER CENT OF TRIPS
0
5
10
15
0 10 20 30 40 50 60 70 80 90 100
TRIP LENGTH (MINUTES)
SOURCE MELBOURNE TRANSPORTATION COMMITTEE

FIGURE 17

average zonal trip length was established using trip generation rates from the Canberra Short Term Transportation Study base year data and TRANSTEP average trip length predictions.

The relationships established for Home Based - Work and Home Based - Shopping are shown in figs. 18 and 19. Due to time and resource limitations, no statistical analysis was performed.

The shape of these functions accord with preconceived notions of trip making behaviour, illustrating the tradeoff implicit in travel budget theory.

An attempt was made to analyse these functions by income categories (High, Medium and Low). There was insufficient data to demonstrate statistical differences, however it appeared that the functions were the same for each income category, but the variance increased with income.

1.4 THE POPULATION DISTRIBUTION MODULE

The calibration of the time/density functions in the population distribution module involved the collation of census population data back into the last century for LGA's in the Sydney Metropolitan Area. Care was taken to adjust where possible for changes in LGA boundaries, when computing gross population densities for each census time period.

The curves for each LGA were then superimposed without regard for the time scale initiation point to provide the closest grouping of time/density curves. In the case of the Parramatta Region Public Transport Study, three calibration curves were derived - a "normal" or closest fit curve, together with higher and lower curves to provide high and low estimates of the population distribution function. Usually the "normal" curve is all that is required.

No statistical analysis of this process is possible so that the module's predictive power was tested between the two latest census years for which data was available, 1966 and 1971. Population growth was predicted for a 200 zone network, which was then compressed for comparison with LGA totals. Very good agreement with census growth figures was obtained although no statistical comparison was carried out due to time and resource pressures.

The accessibility calibration constant k was set at unity for this the only application of the module to date.

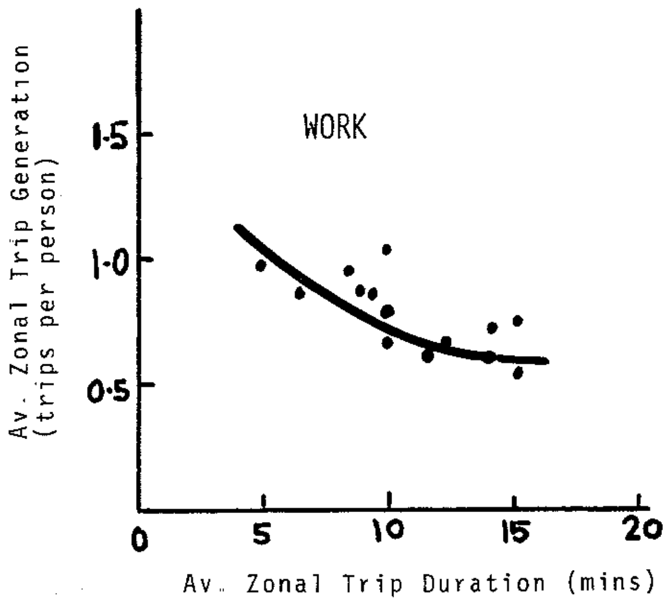


FIGURE 18

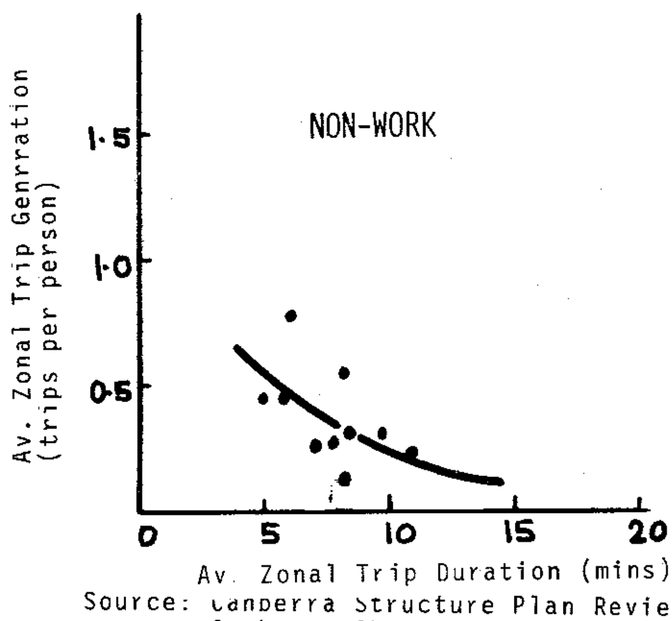


FIGURE 19

Source: Canberra Structure Plan Review
Canberra Short Term Transportation
Planning Study

APPENDIX 5 - EQUILIBRIUM AND LAPSED TIME

The concept of equilibrium incorporates the assumption that adequate time is available for time-lagged variables to have worked themselves out. In an equilibrium situation in which many decision-makers are active it is to be expected that different decisions are made within different time frame references.

For instance the travel path decision to divert between two alternative routes may be made within, say, a ten minute time frame. On the other hand, a decision to relocate employment to reduce travel times is unlikely to be made in less than several months time frame. Land-use decisions may take several years to make and implement.

Further decisions involving short time frames may be implemented without knowledge of, or recognition of, complementary trade-off situations with longer time frame references. Partial equilibrium may be established within a context of overall disequilibrium.

In bringing together a series of decisions involving equilibrium choice, it is vitally important to examine the time frame reference of the models simulating each of these decisions
18 to establish their consistency. The lowest common denominator time reference may be appropriate, but only if demand and supply conditions affecting each decision are consistently modelled over this time frame.

This consideration of time frame consistency may be the biggest difficulty in applying the concept of equilibrium to land-use/transport interactive models. The question deserves much more research than the authors have been free to give it.

APPENDIX 6 - ECONOMICS AND GENERATED TRAVEL

A series of approximations are often made in practise when evaluating user utility and real user cost changes. These approximations are sometimes due to modelling limitations, and sometimes due to cost considerations.

For instance it is not uncommon to find economic evaluation of transport facilities based on a fixed person trip table. The user utility and real costs arising from mode choice
19 decisions and accruing from shorter time or distance paths are approximated by this method. The approximation is usually brought about due to the cost of evaluating changed trip distribution when, say, using conventional 4-stage transportation planning processes.

In these applications:

$$t_{2ij} - t_{1ij} = 0 \quad \text{for all } ij$$

since the person trip table is fixed, and only real user costs can be evaluated.

In applications where trip distribution is carried out, say, by Gravity Model, but trip generation is constant, then:

$$\Sigma\, t_{2ij} = \Sigma\, t_{1ij},$$

and while the trip matrix may change, the evaluation does not include the user utility or costs derived from new trip generation.

A further step involving less approximation is incorporated in models which adjust trip generation rates in response to network congestion. In these applications:

$$\Sigma\, t_{2ij} \neq \Sigma\, t_{1ij}$$

and the economic evaluation embraces all changes in travel patterns due to network influences or effects.

TRANSTEP, because it amends trip generation rates for attraction zone changes as well as production zone changes or network effects, carries the economic evaluation one step further.

It is appropriate to consider carefully the manner in which the economic benefits and costs derived in this way are attributed in respect of capital and operating costs. In an impact evaluation exercise all user benefits and costs that constitute the impact evaluation can be attributed to the cost of the facility causing these effects.

In strategy planning exercises, however, where the cost of all urban development is a variable, care must be exercised in ensuring that net user benefits are not used to justify land development costs in one exercise and then, in another, the costs of urban transport developments. This problem does not arise to the same degree with models which only alter trip generation in response to transport network improvements.